DPD

Director's Rule 13-2006

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Subject: Shotcrete for Structural Applications, Including Duties and Responsibilities of Registered Special Inspectors	**Code and Section Reference:** Seattle Building Code Section 1914	
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	Ordinance Authority: SMC 3.06.040	
Index: Building Code/Technical Requirements	**Approved** _____ Diane M. Sugimura, Director, DPD	**Date**

BACKGROUND

The purpose of this Director's Rule is to establish the minimum inspection and testing requirements of the City of Seattle, Department Planning and Development (DPD) and to provide confidence in the integrity of structural shotcrete. Particular emphasis is given to the duties and responsibilities of the registered special inspector. Other building jurisdictions have found that limiting shotcrete to non-critical systems of a structure was a reasonable manner to obtain confidence. DPD believes that by clarifying the responsibilities of the involved parties, shotcrete can be used with confidence in many situations. Use of shotcrete with these quality controls implemented is a cost-effective alternative to cast-in-place concrete.

REFERENCES

1. Seattle Building Code (SBC) Section 1914
2. American Concrete Institute (ACI) 506R-05, "Guide to Shotcrete," ACI 506.2-95 "Specifications for Shotcrete," and ACI 506.4R-94 "Guide for the Evaluation of Shotcrete."
3. Director's Rule 8-2006, "General Duties and Responsibilities of Registered Special Inspectors."

DEFINITIONS

Shotcrete is mortar or concrete that is pneumatically projected at high velocity onto a surface. It is also known as Gunite and air-placed concrete.

Engineer is the Structural Engineer of Record for the entire project.

RULE

A. APPROVALS REQUIRED BY DPD

Approval of the shotcrete procedure by the Engineer and DPD is required prior to application of structural shotcrete on any project. Approvals are required for the design mix, slump, lift height, nozzler, nozzler's assistant (blow pipe operator), equipment, method of taking compression test samples, and pre-construction testing. DPD approval is for the entire procedure and may be revoked if changes are made without first obtaining DPD approval. Permitted projects which do not specify the shotcrete method of placement shall not use shotcrete without the approval of the Engineer and DPD.

Areas of the structure which are to be shotcreted shall be shown on the permit documents. As an alternate, a written description reviewed and signed by the Engineer may be submitted to DPD for approval at the time of the preconstruction meeting.

B. PRE-CONSTRUCTION MEETING

A pre-construction meeting is required for all projects where the shotcrete method of placement is used. The meeting shall be held after the Engineer has designated areas to be shotcreted and the shotcrete subcontractor has been selected. The meeting shall be attended by the Engineer, the general contractor, the shotcrete contractor, the reinforcing steel placement company, the inspection agency, and DPD. Those present at this meeting shall discuss the number of nozzlers and helpers required for the project, the number of pre-construction test panels, areas where sacrificial steel may be located, the number of cores from in-place work to be taken, the schedule of placing shotcrete and taking cores from in-place work, and acceptability criteria.

EXCEPTION: Where the project meets the criteria for waiving of pre-construction test panels (see Section C below), the shotcrete pre-construction meeting may be waived by the Engineer and DPD.

C. PRE-CONSTRUCTION TESTING

(1) **Nozzler's Qualification Panel.** Each nozzler must shoot a mock-up panel. A mock-up panel shall be shot, cured, cored or sawn, and visually examined prior to commencement of the project in order to demonstrate each nozzler's ability to do the work.

Each shoot of a mock-up panel shall be witnessed by a special inspector registered in shotcrete from the authorized inspection agency for the project and may be witnessed by the Engineer and DPD. Twenty-four hours prior to scheduled shooting of the mock-up panels, notification shall be given to the authorized special inspection agency, the Engineer, and DPD.

The mock-up panel shall represent the project and simulate job conditions as closely as possible. The mock-up panel thickness and reinforcing shall reproduce the thickest and most congested area specified for the structure, as identified by the Engineer. The Engineer shall state which section of the design drawings shall be represented by the panel. Or, where the panel is to be a composite of sections, the Engineer shall provide the contractor with a detailed sketch of the panel. The panel shall be a minimum of 3 feet x 3 feet by the actual shotcrete thickness of the area represented. Reinforcing steel, type of splices, dowels, and embedded items shall be represented in the mock-up panel.

The panel must be shot using the same nozzler, nozzler's assistant, and equipment that will be used on the actual project, and with the same concrete mix design (from the concrete producer who will supply the actual project), and at the same angle as will be used on the project. Where the nozzler will have to shotcrete a lift higher than his/her shoulder height, the mock-up panel shall be set so the maximum height the nozzler will shoot on the job is duplicated in the panel. Concrete used for the actual project shall be within 1/2 inch +/- of the slump used on the test panel. Lift heights on the project shall not be greater than those in the test panel. The panel shall not be shot until the concrete mix is approved by the Engineer and DPD.

When the mock-up panel is to be sawn for visual examination, it shall be sawn diagonally and as nearly in half as practical. When the mock-up panel is to be cored for visual examination, a minimum of three cores shall be taken. Each core shall be 4" in diameter and cut through the entire thickness of the panel. Cores shall be cut at random locations marked by the special inspector, Engineer or DPD. (In general, the center of any core should not be closer than 6" to any edge of the panel except where special members or procedures exist and these areas are considered to be critical to design performance.) Cores shall be intentionally located so as to intersect the most congested resteel intersections. (To identify such intersections in the hardened panel, where the ends of the reinforcing bars do not extend through the panel forms, nails may be placed in the panel form directly over principal reinforcing bar ends prior to shooting the panel.)

Where joint configuration is of primary concern, for example, in top down constructed permanent wall systems, the configuration of the joint shall be part of the test, and acceptance or rejection of the panel shall be dependent upon successful joint achievement as well as on the results of the cores. Additional cores may be required by the Engineer and/or DPD in the area of the joint.

The nozzler's qualification panel shall be completely stripped of their forms and formed sides shall be examined for evidence of sags and delaminations as well as voids, rock pockets, etc. In addition to a visual examination, these formed surfaces shall be hit with a hammer to discover the extent of any defect visible on the surface. The mock-up panel should demonstrate that the nozzler can effectively encase the reinforcing steel without voids, rock pockets, or similar defects, and that he/she can apply shotcrete with an overall dense nonporous appearance.

The cores or sawn surface shall be reviewed by the Special Inspector, Engineer and DPD. They shall discuss acceptability of the quality of work including: number of voids, bar placement, bar cover, and porosity. When the test panels meet the agreed-upon quality, the work may proceed.

The Engineer and DPD may waive their review of the mock-up panel. The Special Inspector may authorize the work to proceed when the panel reveals virtually no defects. The test panels and any cores shall remain on site for follow-up examination by the Engineer and DPD. When the visual examination of the formed and cut or cored surfaces of the shotcrete panel reveals

voids, rock pockets, sand streaks or other defects the Special Inspector shall notify the Engineer and DPD immediately so they may examine the sample(s), and decide whether or not the nozzler's work is acceptable and the shotcreting may commence.

EXCEPTION: The requirement to pass a mock-up panel for a specific project may be waived by the building official provided:

a) All reinforcing bars are #5 or smaller;
b) The minimum spacing for reinforcing bars specified in SBC 1914.4.2 is met;
c) Non-contact lap splices are used with at least two inches of clearance between bars, and never more than 6 inches;
d) There are no pilasters, columns, beams, or other complicated members included in the proposed shotcrete work;
e) No overhead or other especially difficult shooting positions are required;
f) The nozzler or nozzlers who will do the work have been qualified by passing a mock-up panel within the past year, or have successfully shot a project (verified by a minimum of three cores taken from the actual structure) within the past year, and while employed by the same shotcreting firm. You may contact DPD's structural concrete inspector to verify nozzler's prior record.

After all reinforcing steel is in place for the areas to be shotcreted, the Special Inspector or the Engineer and DPD shall verify that the above criteria for approval of the test panel or the exception have been met. Where several members are to be placed at different times, approval may be given for one area at a time.

(2) **Compressive Strength Test Panels.** Provided the shotcrete mix has a minimum of 7 sacks of cement per cubic yard and provided the strength specified is 4000 psi or less, no compressive strength tests are required at the time of the nozzler's qualification panels. Where it is proposed to use a mix with less than 7 sacks of cement per cubic yard and/or where design strengths in excess of 4000 psi are specified, the strength test shall be required at the same time and from the same batch of concrete as the nozzler's qualification panels. (See Section F of this Rule.) Test panels to determine the strength of the shotcrete are also required during the shooting of the actual project.

D. PLACEMENT LIMITATIONS

Where it will take more than one 8 hour work day to complete the shotcrete on a project, more than one nozzler may be required to pass a mock-up panel before the shotcreting may start. No shotcrete shall be placed by any person other than a nozzler pre-qualified and approved for the project. If only one nozzler is approved for the project and that person is unable to complete it for any reason, work shall stop until another nozzler is approved.

When the shotcrete is placed in areas considered to be of significant structural consequence, shotcreting may be suspended after the first day's work until cores can be taken from that work and evaluated. This may be done when the quality of shotcreting produced by a particular contractor or by a particular nozzler is unknown, or is questioned because of a history of poor workmanship on past projects.

E. CORES FOR VISUAL EXAMINATION FROM THE STRUCTURE

Cores shall be taken from the structure during construction for visual examination of the shotcrete, specifically to verify reinforcing steel embedment and bond in the shotcrete and to verify overall density and porosity of the shotcrete. The number of cores required shall be determined by the design team and DPD but shall be not less than three for any project. Sacrificial steel shall be placed in locations designated by the Engineer and cores shall be taken

at the center of the sacrificial steel. Cores must cut through all curtains of steel and extend just beyond the furthest curtain of sacrificial steel.

Where visual examination of cores taken from in-place work show poor consolidation or lack of bond with the reinforcing steel, approval for the nozzler responsible shall be revoked and the placed concrete not accepted. Any core which is taken for visual examination and which cuts through reinforcing steel may not be destroyed until final acceptance or rejection of the represented shotcrete has been made by DPD.

Any core which fails to cut through reinforcing steel is not valid for visual examination of shotcrete quality in the structure.

EXCEPTION: When shotcrete is placed by a nozzler under Section C, exception (2), visual examination may be waived when:

a) total yardage is 100 cubic yards or less; and
b) in the opinion of the building official, no special hazard exists.

F. CORES FOR STRENGTH TESTS

Cores for strength tests may be taken from the actual work or from strength test panels in accordance with Section 1914.10 of SBC. Where strength test cores are taken from the actual work, they shall be discarded if reinforcing steel is accidentally included in the core. Where test panels are used, the qualified nozzler shall shoot the panels at the same angle and in the same manner as the in-place work. Every effort shall be made to assure the concrete in the test panel is representative of that in the actual structure. The strength test specimens shall be protected from moisture loss, temperature extremes, and damage while at the jobsite in accordance with ASTM C31-03.

G. SPECIAL INSPECTIONS

The Special Inspector shall be registered by the Washington Association of Building Officials in Reinforced Concrete and Shotcrete. It is the duty of the inspection agency employing the Special Inspector to provide field training and supervision of the Special Inspector to assure that they are following this rule and good inspection procedures.

The Special Inspector shall follow Director's Rule 8-2006, "General Duties and Responsibilities of Registered Special Inspectors" and SBC Section 1701, and shall follow the recommendations of ACI 506R-05. The inspector's notebook shall contain copies of these documents and this rule.

(1) In addition to general inspection procedures during the mock-up panel for nozzler qualification, the inspector shall:

a) Record the name of the nozzler and the assistant for each panel;
b) Record how the panels are reinforced and note whether lapped splices, dowels, and embedded items are represented. Record the type of splices used (contact with one bar behind the other, non-contact, mechanical coupler, etc.)
c) Record which concrete mix, supplier, pump, compressor, and nozzle are used;
d) Record the slump of the concrete used and the height of the lifts taken in the test panels;
e) Verify that principal steel is marked in such a manner on the outside of the forms so that its locations will be determinable after the panel is shotcreted. Do not allow nails to be pounded into any part of the shotcrete panel forms where there is fresh or green shotcrete. Do not allow nails to be put on the edges of the forms which are parallel to the finished surface where they will interfere with finishing the surface of the panel. Do not allow the use of ink or chalk markers as they will be eradicated by overspray.

(2) In addition to general inspection procedures and procedures required by the inspection/testing agency during the shotcreting of the actual project, the Special Inspector shall also be responsible for the following:

a) Verify that reinforcing steel conforms to project specifications and the SBC. Particular care shall be given to assure resteel is tied securely, is clean, and lapped splices are in accordance with Section 1914.4.3 of SBC. Verify that the splice used in-place is the same type of splice used in the nozzler's qualifying panel (non-contact lapped splices, mechanical couplers, etc.) Verify that sacrificial steel has been added as directed by the Engineer.
b) Verify that no portion of the work to be shotcreted has reinforcing steel more congested (more bars, larger bars, or closer spacing) or is otherwise significantly more difficult to shoot than the "worst case" represented by the nozzler's qualifying panel.
c) Verify that the concrete truck delivery tickets show that the mix delivered is the same as the approved mix. If the batch weights do not appear on the first trip ticket, the inspector shall ask the concrete truck driver to call his/her dispatcher for the weights and write them on the ticket. Subsequent tickets shall show the mix number, cement content, maximum size aggregate and admixtures (if any) and amount of water that may be added at the site.
d) Verify that the slump of the shotcrete is within 1/2" of that used in the nozzler's qualifying panel.
e) No admixtures shall be added at the nozzle unless approved by the Engineer and DPD. (Approval to use admixtures may be given only if accurate measurements of the amount of the admixture being added can be verified for any specific area placed.)
f) Check each load of concrete visually for obvious problems such as wrong size aggregate, high slump, etc.
g) Check forms, previously placed shotcrete, masonry or other material to which shotcrete is to be placed and assure it is free of dirt, standing water, oil, grease, debris, rebound, or any other material that could interfere with the bonding of the shotcrete. Pay particular attention to drainage fabric placed over vertical earth cuts. Make sure the drainage fabric is "nailed" to the earth and does not move during application of shotcrete. (Note: the weight of overspray on drainage fabric can cause it to sag during shotcreting. This is unacceptable and must be corrected.) Notify the soils engineer and DPD immediately if significant cave-ins occur resulting in voids behind the wall where shotcrete is applied directly onto vertical earth cuts. Voids in excess of a few cubic feet and frequent small cave-ins should be reported. All concrete contaminated with earth shall be removed.
h) Before the application of shotcrete verify that the surface to be shotcreted is thoroughly wetted, and that free water does not remain on the surface.
i) Verify that the nozzler, nozzler's assistant, pump, air compressor, and nozzle are the approved personnel and equipment for the project.
j) Verify that guide wires are set at specified thicknesses, are located at intervals sufficient to ensure proper thickness and that they remain tightly strung throughout the placement.
k) Verify that joints are properly cleaned and sloped. If the reinforcing steel protruding from the lift is blown clean immediately after shotcreting stops, additional cleaning of the resteel may not be necessary. However, if overspray is allowed to dry on protruding steel it shall be removed prior to placing additional concrete. Where joints are placed on earth (for example, in top-down constructed permanent wall systems) special care must be executed to keep dirt from being incorporated into the shotcrete. A thin layer of sand shall be used to interface with the shotcrete for all but the cleanest of sandy soils. Also, such joints must be carefully contoured by hand to slope down in the back to accommodate cleaning the joint and placing the next lift down. In top-down construction

after excavating the earth for the next lift down the joints shall be cleaned, with air or water under pressure, to the satisfaction of the Special Inspector.

l) Verify that the concrete deposited in the last pass of a lift is removed by hand. This material is not impacted by a subsequent layer of concrete and therefore is not pneumatically consolidated and must be removed to prevent a weak, porous joint.

m) Verify that no rebound is used to patch holes or otherwise reintroduced into the work.

n) Verify that resteel does not move during application of shotcrete.

o) Verify that the nozzlers are using good ACI 506R-05 placement technique, paying particular attention to angle of placement, distance of nozzle to work, even distribution of concrete on the work surface, depth of pea gravel impact craters, etc. Monitor the consolidating of the shotcrete by making sure the nozzler keeps the nozzle moving sufficiently to prevent shotcrete from swelling out around the impact area (such material is not pneumatically consolidated and is not acceptable).

p) Continuously maintain an observation position a few feet from the nozzler during actual shooting while remaining aware of the laborers moving pump lines, scaffolding, cleaning up rebound, etc., and stay out of their way.

q) Verify that the nozzler's assistant is in continuous attendance and keeps rebound blown out so it is not incorporated into the work. (Additional workers may be required to remove rebound if it cannot be removed by the air blow pipe.)

r) Verify that any area which sloughs off is removed and reshot. The shotcrete above and behind any sloughed off area may have moved when the slough off occurred. Any movement by adjacent shotcrete will result in voids around the resteel in these areas and is unacceptable. Cuts to remove shotcrete shall be vertical and perpendicular to the surface of the member. Where, in the opinion of the Special Inspector, movement may have occurred adjacent to a slough off, the shotcrete in question shall be removed.

s) Verify that samples for compressive strength tests are shot and stored in accordance with SBC 1914.10.

t) Verify that cores are drilled in accordance with the approved shotcrete procedure and schedule, and in the locations specified by the Engineer. (Unless otherwise specified by the Engineer, cores are drilled 2 days after the shotcrete is placed. If this does not happen the inspector shall notify DPD immediately.)

u) Verify that specified curing procedures are followed. Verify that no material which may interfere with bonding is used in areas where finishing plaster coats, additional shotcrete lifts or other cement products will be applied. (Note: Where applicable, only water soluble curing compounds which will not interfere with the bond of additional concrete shall be used. Where shotcrete is cured with a chemical curing compound, good construction practice is to use two applications on vertical shotcrete members, the first being placed immediately after finishing the shotcrete surface, the second 8 to 16 hours later. Each application should be at twice the manufacturer's recommended rate for horizontal surface.)

v) Notify the shotcrete contractor immediately if shotcreting should be discontinued because of heavy rain, high wind, or low ambient temperatures (40 degrees F or less).

w) Promptly report to DPD and the Engineer any deviation from ACI 506R-05, SBC Section 1914, or this rule, and immediately report any observed defect which was not corrected.

x) In addition to the general information required for all inspection reports (Director's Rule 8-2006) the shotcrete inspector shall report the names of the nozzler and nozzlers assistant, the brand names and types of pump, compressor, and nozzle; heights of lifts, slumps, total yardage used, and the type(s) of test samples taken.